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(54) Recovery of Oil From Tar Sands

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Abstract of the Disclosure

Oil is recovered from tar sands by causing a gas, heated to a temperature within the range from 300°C to 600°C, to flow downward through an enclosed mass of tar sands to cause an oil fraction to separate from the mass by gravitational flow and the separated oil fraction is recovered. The gas may be an inert gas or an active gas. The process may be carried out on masses of tar sands separated from the deposit or in-situ.

This invention relates to the recovery of oil from tar sands.

There are in Western Canada huge deposits of tar sands containing useful oil fractions. However, recovery of the oil is complex, difficult and costly.

A principal surface process for the recovery of oil from tar sands is by hot water immersion followed by extraction of the oil fraction. In the case of subterranean deposits, high pressure steam, at a temperature of about 300°C, is injected into the oil-bearing formation for a period of several months, following which the steam is cut off and oil from the heated formation flows to a sump, whence it is raised to the surface. This is known as the "huff and puff" system. In a variation of this system, steam may be introduced into an injection well and after heating the tar sands to 300°C to 400°C, the oil fraction, separating from the sand, is driven towards a connecting production well.

These processes are complicated by the fact that, where steam is used, it has to be conveyed from a source, through insulated piping. Also, its thermal efficiency is not more than about 30%. A further complication is that residual water mixes with the oil fraction to form an emulsion from which it is hard to separate the oil.

It is an aim of the present invention to provide a process for recovering oil from tar sands which avoids these disadvantages and provides certain positive advantages as will be seen from the following description.

A process according to the invention comprises causing a gas, heated to a temperature within the range

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from 300°C to 600°C, to flow downward through an enclosed mass of tar sands to cause an oil fraction to separate from the mass by gravitational flow. The oil fraction is recovered after being forced from the bottom of the retort by the pressure of the incoming gas.

Gases which may be used are inert gases, for example, nitrogen ~~hydrogen~~, argon, helium, carbon dioxide, or active gases, for example, hydrogen or oxygen. In the case of the use of an inert gas, the mixture of gases formed within the mass and emanating therefrom are recovered and the inert gas stripped from the product gases combined with makeup gas, heated and recycled through the mass. Where a hydrocarbon gas is used, it dissolves the hydrocarbon fluid within the tar sands to provide a fluid of lower density, which is recovered.

In the case where oxygen is used, heat is generated by the ensuing combustion of some of the hydrocarbon within the mass, the resulting oil fraction is recovered together with carbon dioxide and water from the reaction. The latter are separated from the oil fraction.

The invention will be described in more detail, by reference to the accompanying drawings, which illustrate preferred embodiments and in which:

Figure 1 is a diagram showing a typical recovery plant employing an inert gas;

Figure 2 is a graph showing the results of using an inert gas.

Referring more particularly to Figure 1, the preferred process illustrated proceeds as follows. A

mass of tar sands, from the Athabasca Tar Sand Fields, is placed in a retort B (or this may be a number of retorts in series or in parallel). Hot nitrogen, at a temperature of 450°C is introduced into the retort B from the line J. Passage of the hot gas through the retort B first heats up the mass of tar sands to operating temperature and then causes a gravitational flow of the tar sands assisted by the downward flow of the inert gas. The oil fraction is forced from the bottom of the retort by the pressure of the incoming gas and passes to an oil-gas separator D. The oil is removed from the separator D and the gas conveyed through a line F.

Off gases coming from the tar sands are bled off at G, while the nitrogen passes through the line H, which is also supplied with fresh hydrogen and flows into the gas regenerator I. The nitrogen is heated in the regenerator I and passes through the line J and back into the top of the retort B.

The spent tar sand, which is a fine particled relatively dry siliceous mass, is then removed from the retort B and replaced by additional mass of tar sands.

Alternatively, the invention contemplates an in-situ procedure, either to treat surface or subterranean tar sand deposits, specially the latter.

It is seen that, according to the process, described, the gas is heated to a predetermined temperature and is then circulated through the tar sands. The effect is to warm the tar sands to the point where the oil separates. It then drains by gravity to a sump heated by

the circulating hot gas or gases which flow in the same gravitational direction.

In selecting a gas, suitable for this process, one must consider the results to be achieved. For example, where it is desired to extract the oil from the sand without any reaction, then there may be selected an inert gas, for example, nitrogen, argon, helium, or CO_2.

Nitrogen has proved specially effective when applied to tar sands of the Athabasca type. Where a tar sand formation is extremely dense and, therefore, quite impervious, helium would be preferable to nitrogen.

Under other circumstances, where it is desirable to lower the density of the oil, before pumping to the surface, carbon dioxide would be a preferable gas because of its miscibility in oil.

Under other circumstances, it may be desirable to achieve a partial cracking of the hydrocarbon in order to generate heat. In this case, various concentrations of oxygen, above 70%, and including pure oxygen (99.5%) may be introduced into the tar sands to provide heat through partial combustion.

Further, one might wish to use hydrogen because of its good heat transfer properties and low density. The introduction of hydrogen may, under suitable conditions, produce hydroforming.

Other suitable gases for oil extraction are related hydrocarbon gases, for example, methane, ethane, propane, or butane.

The optimum temperature is that which extracts

the greatest amount of oil. The applicants have found that a temperature between about 300°C and 600°C, preferably 400°C and 500°C, makes it possible to extract up to 85% of the oil contained in the sand. Surprisingly, the oil fraction has a viscosity, at 20°C, comparable to that of lubricating oil. This product has the advantage over the heavy bitumen product extracted by steam methods which, at room temperature, is not fluid and requires special insulating precautions to keep it fluid.

The process may be applied to tar sands which are mined at the surface, for example, the Athabasca Tar Sands. It may also be used for in-situ recovery where the oil-bearing formation is located 500 metres or more beneath the surface, for example at Cold Lake, Alberta.

The invention will be further illustrated by reference to the accompany non-limiting example.

Example

A mass of 600 grams of Athabasca tar sands containing about 14% volatiles by weight, was treated with hot nitrogen (400°C) substantially as described above by reference to Figure 1. The amount of oil extracted was 71.4 grams. This represents a yield of about 85%. This was achieved in not more than 30 minutes, including the initial heating of the mass to extraction temperature.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A process of recovering oil from tar sand, comprising,

enclosing a mass of tar sand, made up of oil entrained in a fine particled siliceous material, within an enclosed elongated vertical retort vessel having gas and solids entrances at the top and gas and solids outlets from the bottom and an enclosed unobstructed direct passage extending between them,

causing a gas, heated outside the vessel, to a temperature within the range from 300°C to 600°C, to flow into and downward through the passage in contact with the enclosed mass of the tar sand to cause its heating to operating temperature and to cause a liquid oil fraction to separate from the siliceous mass by gravitational flow and by the pressure of incoming gas and to be forced with entrained gas through said gas outlet leaving in the vessel a fine particled relatively dry siliceous mass,

recovering the oil fraction so separated from entrained gas,

and recovering the siliceous mass from the vessel.

2. A process, as claimed in claim 1, in which the gas is an inert gas.

3. A process, as claimed in claim 2, in which the gas is nitrogen, argon, helium, or carbon dioxide.

4. A process, as claimed in claim 1, in which the gas is an active gas.

5. A process, as claimed in claim 4, in which the gas is hydrogen.

6. A process, as claimed in claim 4, in which the gas is oxygen.

7. A process, as claimed in claim 1, 2 or 3, in which the gases emanating from the mass are recovered and the inert gas stripped from the product gases then combined with makeup gas, heated and recycled through the mass.

8. A process, as claimed in claim 1, in which the gas is a hydrocarbon soluble in the hydrocarbon fluid of the tar sands.

9. A process, as claimed in claim 8, in which the hydrocarbon gas dissolves in part of the hydrocarbon fluid to provide a fluid of lower density, and recovering said lower density fluid.

10. A process, as claimed in claim 1, in which the gas contains oxygen whereby part of the oil in the tar sand is burned to produce a partial cracking of the hydrocarbon to provide heat.

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11. A process, as claimed in claim 1, 2 or 3, in which the gas flowing into and downward through the passage contains oxygen, whereby part of the oil in the tar sand is burned to produce a partial cracking of the hydrocarbon to produce heat and in which the gases emanating from the mass are recovered and the inert gas stripped from the product gases and combined with make-up gas, heated and recycled through the mass of tar sand.

8

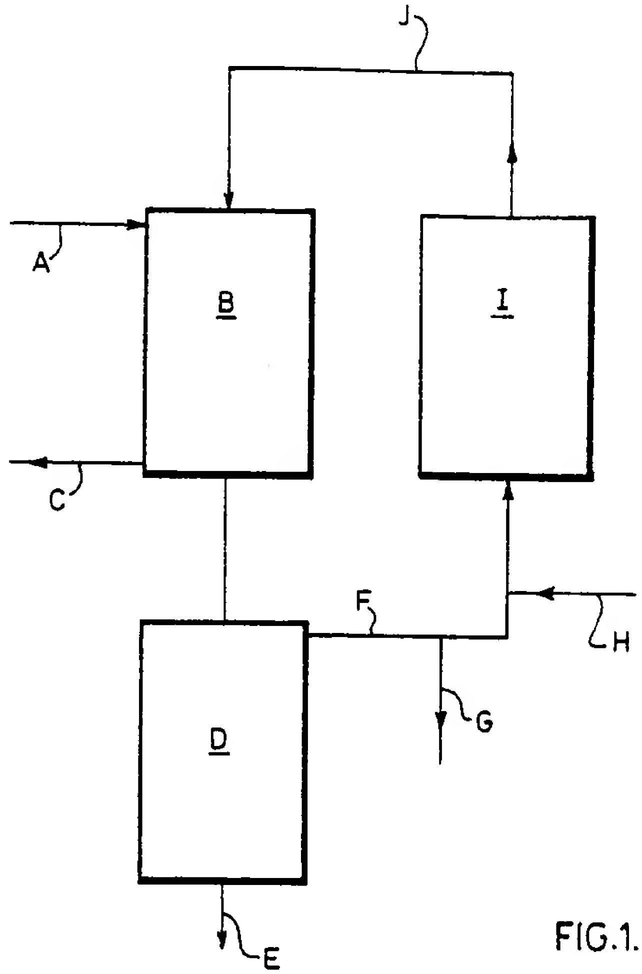

FIG.1.

PATENT AGENTS

Swaby, Mitchell, Houle, Marcoux & Sher

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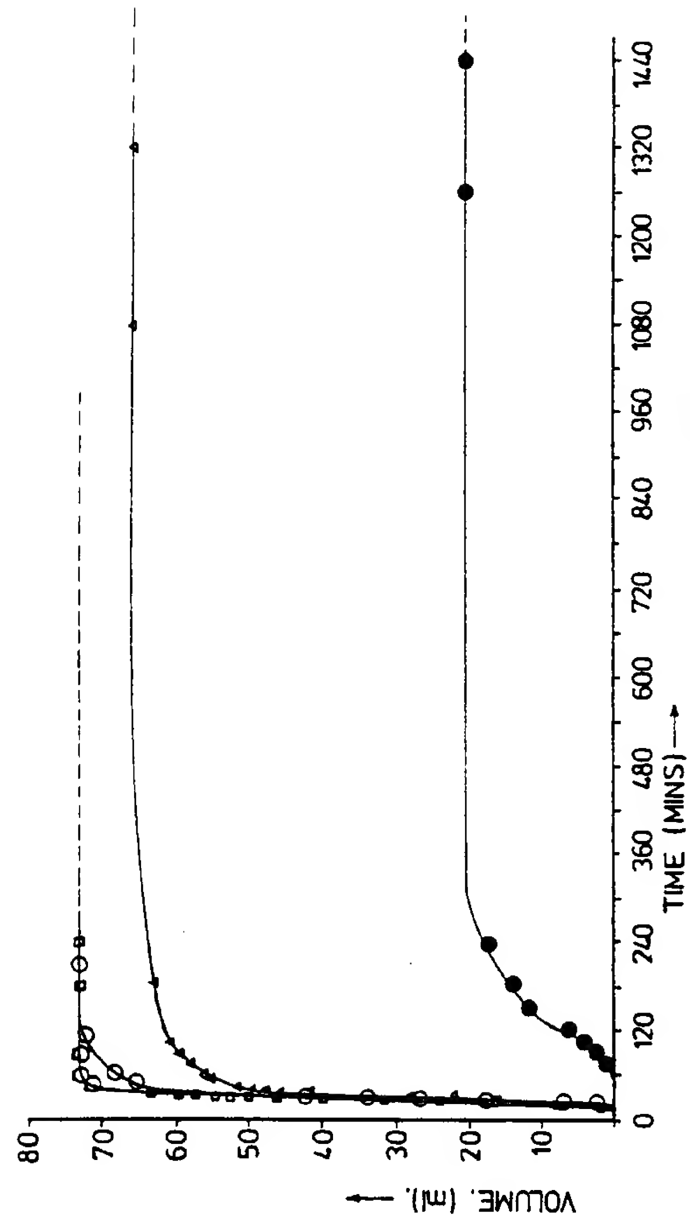

FIG. 2.

PATENT AGENTS

Swabey, Mitchell, Houle, Marcoux & Sher